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OPPORTUNITIES IN MATHEMATICAL STATISTICS, WITH SPECIAL REFERENCE TO SAMPLING AND QUALITY CONTROL[1]

By Dr. W. EDWARDS DEMING

BUREAU OF THE CENSUS AND BUREAU OF THE BUDGET

Seed haunted by the sun never fails to find its way between the stones. And the pure logician, if no sun draws him forth, remains entangled in his own logic.
—*Antoine de Saint-Exupéry, The Atlantic,* March, 1942: page 328.

THE control chart was devised by Shewhart in 1924 to help disclose the presence of extraneous causes of variability that are worth looking for; also to give greater quality assurance in devising acceptance procedures (Problems B and A, respectively, as outlined below). If this were a group of business men, I might seize this opportunity to persuade you to make use of these methods. But speaking before mathematicians, I need not do that. Here we can talk about the next step, *viz.*, how to harness the efforts of mathematicians to statistical problems.

I shall remind you of two problems that confront the manufacturer and the statistician in industry:

Problem A: What to do with this lot? (Accept it, reject, pass, scrap, rework, or regrade it)

Problem B: What to do with the process? (Leave it alone; or look for some identifiable cause, make some adjustment, use different raw materials)

The quality control engineer does his best work in either problem when he recognizes the existence of both, and deals with both simultaneously. In par-

[1] An address given at a joint session of the Institute of Mathematical Statistics and the American Mathematical Society, Vassar College, on September 9, 1942.

ticular, the decision whether to accept or reject a lot of manufactured articles can not be dissociated from the question of control: is this lot one of a series of lots that were made in a state of statistical control? If the answer is no, each lot must be examined in considerable detail if its quality (average diameter or per cent. defective) is to be determined accurately. If the answer is yes, and if the lots are large, inspection of a small percentage of each lot, or of every k-th lot, will give the needed quality assurance. This *increased quality assurance* with *decreased inspection* is one of the advantages of the Shewhart methods.

The Shewhart methods are equally important in the social sciences, where a similar division of problems exists, though with some necessary modifications.[2] With the increasing number of surveys of local and national scope being carried out to supply data on the social and economic states of the population, and on natural resources and stocks, and with the ever-increasing need for accuracy in predictions, the requirements being placed on sampling methods and the interpretation of data are assuming increased severity. Recognition of the importance of sampling is one of the things that brings us together here.

Statisticians and mathematicians are rendering meritorious service in these critical times. I shall try to show you how they can render still more.

Variations in Nature

He who ignores the inherent variability of all nature does not understand nature. You may leave home at the same minute morning after morning, but you do not always arrive at your office at the same time. The peas in a pod are not alike, but they are usually alike enough for the purpose. Two telephones are not alike, but the variations are within limits that are known to be close enough and known in advance of production. Traffic accidents, deplorable though they are, do happen, and what is more, *will fluctuate week by week,* even under a constant set of causes. Likewise, a sentence will have various meanings, depending on who reads it. The meaning of anything that you say is the *action that it produces.* In attempting to write clearly you can only hope to narrow the spread of the interpretations—*i.e.,* of the actions or emotions that your writing gives rise to when readers read it.

I heard that the president of one large corporation was always anxious whenever the amount of scrap was greater one day than it was the day before. Now of course it is well to get interested in scrap, and the control of scrap incidentally offers one of the best uses of the Shewhart control chart; but if one looks for trouble in the plant every time the amount of scrap is higher one day than it was the day before, he will be looking for trouble far too often. It costs money to look for trouble. The amount of scrap is going to vary day after day even under controlled circumstances (*vide infra*).

Definition of a Constant Cause System

A constant cause system may be described as one that produces numerical results that vary from one to another like a sequence of numbers that are drawn from a bowl of physically similar numbered chips, blindfolded, and with replacement and shuffling. Drawing from a bowl is the limiting attainable state of knowledge, which is to say, this is the limiting attainable state of stability.

The prime requirement of a constant cause system (a controlled process—*vide infra*) is stability, and hence the predictability of future percentiles or probability tolerances. It is important to recognize that a constant cause system does not produce constant results.

Randomness, Statistical Control and Technical Control

Any observation, measurement, or table of frequencies, comes about as the result of applying an operation. Whatever the operation, a repeated application thereof gives a new observation. Continued repetition gives a sequence of terms—a *population* of results. Thus, suppose an article is being manufactured, one after another, and let each be measured for its outside diameter. The situation is something like this—

$$\begin{array}{ll} \text{Article:} & F_1,\ F_2,\ F_3,\ \ldots,\ F_n \\ \text{Diameter:} & X_1,\ X_2,\ X_3,\ \ldots,\ X_n \end{array}$$

The manufacture and the testing and the recording of the diameters constitute the operation of obtaining the n values of X.

In the state of randomness or stability, the terms of the sequence behave as if they were being produced by a constant cause system—they behave as if they were being drawn from the bowl. Without stability, probability tolerances for future terms can not be set purely on the basis of past terms.

The attainment of randomness is much more difficult than is commonly supposed. It may require months. Statistical control is more than technical control. In the latter, the terms of the sequence are merely kept within certain bounds. Be they ever so narrow, this is not statistical control. Of course, technical control comes first, and is often sufficient.

A practical criterion of stability is the Shewhart criterion. If 25 or more successive points, each consisting of four consecutive terms of a sequence, fall within the control limits, after it is thought that all possible sources of extraneous variability have been

[2] These remarks are extended in my paper in the *Jour. Am. Statistical Assoc.,* June, 1942, Vol. 37, pp. 173–185.

eliminated from the process that gives rise to the sequence, and if no trends or patterns are exhibited by the sequence, it is possible to set probability tolerances on future terms of the sequence, and thus to predict how much of tomorrow's product will fall within various limits—possible in the sense that experience, in many different kinds of production, covering many years, has borne out the advisability of so doing. I shall return to this topic later.

THE FUNDAMENTAL PROBLEM OF MATHEMATICAL STATISTICS

The fundamental problem of mathematical statistics is to set "probability tolerances," *i.e.,* to set limits within which 99 or some other per cent. of the next (*e.g.*) 1,000 or 10,000 terms of a random sequence will fall. For instance, on the basis of the past n diameters in the example cited above, the problem is to say what proportion of the next 1,000 or 10,000 diameters will fall within the limits X_1 and X_2. Failure of the putative percentage of terms to fall within these limits may be taken to indicate the presence of an "extraneous cause"—a cause not associated with the constant cause system identifying the random operation by which the past n terms of the sequence were generated.

The need for predictions in the form of probability tolerances as a basis for action is recognized much wider than it was a few years ago. Examples of action that are supposedly based on probability tolerances can be drawn from almost every field of scientific endeavor. For instance, no measurement, no survey, would be considered worth publishing unless there is evidence that repetitions would duplicate it within stated limits. Take government planning based on census returns; action can be based on the returns only if the census (whether by complete count or by sample) is carried out in such manner that repetitions of the survey, on or near the census date, would result in tables close enough to those that are actually published by the Census—*i.e.,* close enough for the purpose intended. The standardization of a drug is a problem in probability tolerances; dosage (future action) is based on the potency of the drug as determined by experiments which are carried out to make it possible to state in advance the limits within which 95 or 99 per cent. of the next 1,000 or 10,000 tests (results of doses) will fall. Recommendations regarding the planting of next year's crops should be based on predictions in the nature of probability tolerances for future yields, in terms of certain operations (variety, treatment, fertilizer). The prediction of ability for the selection of personnel calls for probability tolerances.

When probability tolerances for future terms of a random sequence are to be set on the basis of past terms alone, mathematical statistics is involved in the pure state—a problem of Type A as I have elsewhere classified the problems of statistical inference.[2] When the sequence is not random, the problem is not entirely mathematical, and may even be hardly at all mathematical; recourse must then be had to whatever knowledge there is concerning the underlying causes that make the terms of the sequence behave as they do. The problem is then one of Type B. The problem is partly or mostly Type B when there are not enough terms in the past, even though they are random, to allow probability tolerances to be set close enough for the purpose by mathematics alone. Often there is only one term, one result, one experiment; the rest is knowledge of the subject-matter.

THE SHEWHART CONTROL LIMITS ARE ACTION LIMITS; THEY STRIKE AN ECONOMIC BALANCE BETWEEN TWO KINDS OF ERRORS

Briefly, the Shewhart methods consist of studying a sufficiently large quantity of data, not as a single sample, but in a sequence of rational subseries that are obtained by breaking up the data in a manner that will indicate with a minimum amount of data the presence of extraneous causes, and the existence of stability when stability exists between the subseries. The most useful way of breaking up the data into subseries must be determined in each problem by knowledge of the subject-matter, but there are some guiding principles to keep in mind. It is important to collect the data and plot the points without delay, in order that action can be taken in time to ward off trends that are not wanted.

The presence of extraneous causes worth looking for is indicated by failure of a point on the control chart to fall within the "control limits." The problem of setting probability tolerances and control limits is a problem in action: What to do? to look or not to look for an extraneous cause? There must be an economic balance struck between the two kinds of errors—looking for trouble that does not exist, and failing to look for trouble that does exist.

There is not time here to tell you how to go about calculating and plotting a control chart and how to draw the control limits. I can use my time to talk about principles. The routine is simple enough, but a good many hours are required to become familiar with it. Fortunately, with the publication of the American War Standards,[3] and Colonel Simon's book,[4] it is possible now to point to a pretty full account of the steps in application.

[3] See references further on.

[4] Col. Leslie E. Simon, "An Engineers' Manual of Statistical Methods," John Wiley, 1941.

What Opportunity is There for Mathematicians?

In talking to a group of mathematicians I should like to seize this opportunity to point out where future emphasis in mathematical statistics must be directed if the present needs of the country are to be met. The accompanying diagram shows what part of the field has been tackled, and what remains. Most mathematical statistics has so far dealt with the central part of this diagram, where randomness exists—statistics *in vitro*. There are exceptions; Professor Wilks,[5] for instance, has made excursions of far-reaching importance into the right-hand part.

Past	Randomness attained here ↓	Present ↓ Future
Randomness being attained here, perhaps requiring months. The Shewhart methods assist, but so far there is but little mathematics, though there is some (theory of runs; the Wallis-Moore test). More mathematics needed.	Randomness exists here. Statistical distribution theory applies. Here is where most of the mathematical work has been done. More needed.	Predictions required in the form of probability tolerances, as a basis for action, and for identifying extraneous causes. The Shewhart methods work; also the mathematical methods of Wilks. More mathematics needed.

Diagram of the Statistical Study of Causes

The practicing statistician welcomes all the distribution theory that has been developed to date. Far from there being too much mathematical statistics, even in the state of randomness there is not enough! With more time I could describe, for instance, some fascinating unsolved problems in distribution theory of great economic importance, and of extreme difficulty, that have arisen in the work of the Census.

Mathematicians have too often assumed that it is easy to produce random variates. It is easy to assume that, and the problems are interesting. Of course, not everything is or should be useful, and we should be thankful for that, but the usefulness of much mathematical work in statistics has often been greatly overestimated because randomness is presupposed, with no indication given to show how far the calculations are invalidated by lack of randomness and what to do in the absence thereof.

Urgent requirements of government and industry now challenge the best mathematical talents in the country. In spite of the volumes of texts and periodicals that have appeared in the statistical field, there are parts of the subject yet untouched—one could almost say yet unrecognized. The need is urgent: the opportunity is great. New tools, new channels of thought are being called for. For one thing, the new mathematical developments in the left-hand side of the diagram must take account of the *order of the observations,* as is already done in the theory of runs and in the Wallis-Moore test, for example.

The requirements of the present and immediate future, when recognized, may turn out to be the sun that draws forth the best efforts that mathematicians have to offer.

[5] S. S. Wilks, *Annals of Mathematical Statistics,* 1941: pp. 91–96. At the Vassar meeting Professor Wilks expounded and extended his published work.

Other Future Requirements

In the future there will be increased attention to the operational point of view, by which I mean that statements made by statisticians will of necessity be confined more and more to statements that theoretically at least can be subjected to test, because their statements will be tested.

The Shewhart methods were devised for the two extremes, right and left, in the diagram. The Shewhart methods work! In the future, mathematicians will show why these methods work and will then set out to improve on them. Meanwhile, it is important that men in government and industry be taught how to use them (*cf.* the last section).

Theoretical statisticians have too often evaluated the methods of quality control in terms of their own theories, without stopping to acquire an appreciation of the problems that face the practicing statistician, who must stand by and see his predictions put to a test. For instance, I have seen it argued (innocently enough) that people in quality control ought to use the nomenclature and language of the theory of estimation.

There will be increased attention to the distinction between chance as defined *a priori* as a basis for theoretical calculations in probabilities, and the meaning of the word chance when it is used to designate relative frequencies predicted to fall within certain limits in a controlled experiment. Calculated chances are one thing, but actual observed frequencies, even under a constant cause system, may be another. In other words, it is necessary to recognize the distinction between what is in the bowl, as determined by some standard method of examining part or all of the chips, and what we get by performing some other operation on it. One can not set probability tolerances regarding the results of drawing from the bowl, purely from knowledge of what is in the bowl as determined by some standard method.

For example, the phenomenon of the undercount of children under 5 is well known among sociologists.

Whether the census is taken by complete count or by sampling, the undercount of young children makes its appearance. How do we know? In the same manner in which it was discovered many years ago. In the census 10 years hence, with allowances for deaths, and for in and out migration, there will be more children of age 10–15 in any sizable area than there were children of age 0–5 ten years before. The phenomenon invariably repeats itself, in this country and elsewhere. People just will forget the baby when the Census man comes!

In this illustration, the count 10 years hence is the "standard measurement." The census method of counting the children of age 0–5 at the date of the first census is the other operation. If it were repeated at small intervals of time, it would perhaps show statistical control. Suppose it does: neither the average result nor the probability tolerances for this "other" operation can be determined *a priori* by the standard count. Likewise the converse: it is too much to hope that the standard count could be determined by the average result or the probability tolerances for the census operation of counting children of age 0–5.

Some Remarks on the Practice of Statistics

Faced with realities, it is sometimes difficult for the practicing statistician to frame his problems in the language of the theoretical statistics that has so far been developed. The problem of attaining control, for example, is not analysis of variance, is not a test of significance, is more than a problem in probabilities, and more than a problem in the statistical testing of hypotheses in the usual sense. It is a problem in *action*. The control limits must provide an answer to the question: What to do? Shall we or shall we not look for trouble? An economic balance must be struck between two kinds of errors (*supra*). The question is not whether an extraneous cause is operating to make a point plotted from inspection data fall where it does (inside or outside the control limits): the question really is *whether it pays to look* for an extraneous cause (trouble).

What Can Be Done?

Now is the time to do something. Statisticians have a great deal to offer. Let them bring it forth. The following 7-point plan is offered as a starting point, to be replaced by better suggestions as experience develops.

i. *Intensive courses in quality control.* By intensive I mean intensive, covering 7, 8, or 10 days, including Sundays, 8 hours per day. Stanford University gave such a course in July, and another in September. Thirty-two picked delegates from industry attended in July, and 31 in September. They were not just college students or graduate students who might some time go into industry and have use for the course. As I say, *they were already in industry.* Most of them were well advanced in their organizations, with authority to try out statistical methods, and they went home with the ability to do so. The 80 hours' instruction was sufficient to give them an excellent start. All phases of the subject were taught, including diagnosis of data brought to the conference, and arrangements for continuation study afterward. The instructional staff at Stanford was supplemented by practical men from government and industry—a vital necessity in such undertakings.

Something similar is being done in Great Britain, and can be done by other institutions of learning in this country. A semester course in quality control is good so far as it goes, but it is not sufficient for the present needs. It is too slow, and the yield too low. The important thing is to give intensive courses to men in industry, now, patterned after the ones at Stanford.

The Ordnance Department some months ago commenced an educational program in quality control under the direction of Mr. G. D. Edwards, of the Bell Telephone Laboratories, who with Mr. H. F. Dodge, of the Bell Telephone Laboratories, and Mr. G. Rupert Gause, of Colonel Simon's staff at Aberdeen, are holding three-day schools for ordnance people in a number of key cities.

With the close relation between price control and quality control, and the necessity for quality determination and the standardization of textiles, foods, drugs and hospital supplies, the need for expert statistical work in this line is multiplied manyfold under present conditions.

The Farm Management Statistical Clinic held under the guidance of Professor H. C. M. Case at Urbana in September, 1941, was an example of a step in this direction.

ii. *Intensive courses in other fields.* Fields other than quality control could be covered by intensive courses for the benefit of men in government and industry. For example, something could be done in the way of teaching statistical methods in psychological tests for placement of personnel.

iii. *Modification of instruction in regular courses.* In regular courses of instruction, students have often been given an incomplete picture of the problems of mathematical statistics. The middle part of my diagram has been taught, and rightly so, but the student has not realized that he was being taught in only this limited portion. The result has been over-confidence in his ability, nonsense calculations and outright mistakes that might be serious if not caught, with consequent mistrust of statisticians. Of course, it is impossible to equip a student of statistics with all that he is going to need, and to give him full directions about just what to do in every situation. Every problem requires intricate tailoring of general principles. This will always be true, but the teaching of general principles has not been broad enough, and what is worse, the student has not been advised and warned of his deficiencies.

iv. *Short monographs on various statistical procedures.* All over the country I have found men in industry, in government and in research organizations eager to learn the tools that the statisticians have developed. From

everywhere comes the question: "Where can I learn more about this? Is there anything printed in simple language that I can understand?"

Here again, something can be done, and is being done. I can refer you, for instance, to the American War Standards in the field of quality control. With remarkable foresight, perceiving the coming need for statistical methods in war industries and ordnance inspection, the War Department in December, 1940, asked the American Standards Association to develop concise treatments for the application of statistical methods, for use both in acceptance inspection, and during manufacture. A committee was appointed, with the result that two standards appeared in May, 1941, and a third in July, 1942, with titles as shown below:[6]

1. Guide for Quality Control, 1941
2. Control Chart Method of Analyzing Data, 1941

(Nos. 1 and 2 are bound together and sell at 75¢)

3. Control Chart Method of Controlling Quality During Production, 1942: 75¢.

These serve as guides in application and for introductions to texts and other books on the subject, and they contain references to texts and monographs on the subject for further study. Similar brochures on procedure could be produced for other statistical techniques.

v. *References to current articles and books in various fields.* The Institute of Mathematical Statistics and the American Statistical Association could perform a valuable service by running in each issue of their journals a list of references to current articles and books on applied statistics, broken down into various fields—sampling in social and economic surveys, quality control, psychological tests, presentation of data, and other subjects. Promptness is more necessary just now than completeness. Work should be commenced at once, with a three months' deadline for the first list, which should be an attempt to show important articles and books that will be helpful to statisticians in practice. The list would be kept current, and omissions filled in, by lists in subsequent issues.

Not all statisticians take the journals. The lists should be offprinted and advertised for sale separately: people would be glad to pay for them; the question is where can they buy them? Offprints of this nature, readily obtainable, would be excellent advertising for both the association and the institute, because they would show the public that these organizations are alive to present statistical needs and are perhaps worth belonging to.

Here is a splendid opportunity for some one not already overburdened by war work to get into it. The project could even be expanded, by the right person, to provide abstracts or films of foreign or rare articles worth looking at.

vi. *Exposition of methods in published articles.* In both journals, there could be more serious attempts to show the reader how to apply the methods that are presented. No matter how theoretical an article may be, it should nevertheless describe how its contents affect present practices. It should contain directions for application, plainly marked, "Step 1, Step 2, do this, do that, . . ." The hypotheses and conclusions and logic should be described in non-mathematical terms, as well as by strict mathematics. In other words, when a writer has something useful, he should say so, and make it possible for others to see why and how to use it. Incidentally, he should not expect the editor to do this for him.

vii. *Expert assistance.* This is the most vulnerable of my suggestions, but I think that some good might come of it, even if it leads to numerous failures. The fact is that there are not enough good men in applied statistics nor in mathematical statistics. There never have been. Right now, all over the country, there are young men grasping, groping, struggling with statistical problems on which action will be taken on a deadline. To whom can they look for assistance? If it could be made known, and if we were prepared, the association and the institute could assist by acting as a clearing house for statistical questions, by referring them to the right man, or by sending the names of experts who can and will go outside of Washington, New York, Chicago, and a few other places, and get their hands dirty. Expenses and a consulting fee would of course be paid; that presents no difficulty. What we need is some one in one or both of the organizations to take active charge of this project.

OBITUARY

EARLE RAYMOND HEDRICK

PROFESSOR EARLE RAYMOND HEDRICK, vice-president and provost of the University of California at Los Angeles, emeritus, died on February 3, 1943, at Providence, R. I.

He was born at Union City, Indiana, on September 27, 1876. He attended the University of Michigan (A.B., 1896), and was Parker Fellow from Harvard (A.M., 1898) at the University of Göttingen 99–01, receiving his Ph.D. in 1901. He attended the École Normale Supérieure, Paris in 1901. Dr. Hedrick was an instructor in mathematics at Yale University from 1901 to 1903, and professor at the University of Missouri from 1903 to 1924. He was professor of mathematics at the University of California at Los Angeles from 1924 to 1937, and served as provost and vice-president from 1937 to 1942. Since October, 1942, he was visiting professor at Brown University.

Throughout his life he was always greatly interested in the teaching of mathematics from secondary school to graduate school. In collaboration with the late C. A. Noble he translated the first third of Klein's "Elementarmathematik vom höheren Standpunkte

[6] Published by the American Standards Association, 29 W. 39th Street, New York. Reissued in Great Britain by the British Standards Institution, 28 Victoria Street, London, S. W. 1. The committee consisted of H. F. Dodge, Leslie E. Simon, W. Edwards Deming, Ralph Wareham, A. G. Ashcroft and John Gaillard.

aus," which rendered great service to teachers of mathematics in this country. A similar service was also rendered by his publication (with the late O. D. Kellogg) of "Applications of Calculus to Mechanics," in 1909. He was author of a college algebra and editor of some 25 volumes in the Series of Mathematical Texts.

But the most important activity during most of this long period was as member or director of various national organizations. He was one of the founders and the first president of the Mathematical Association of America, an organization which has moulded the development of collegiate mathematics since its foundation in 1916.

His contribution to the American Mathematical Society may be summarized by stating that he was editor-in-chief of its *Bulletin* from 1921 to 1937, a member of its board of trustees three full terms of five years each, president from 1929 to 1931 and representative of the society in the National Research Council from 1931 to 1934. Volume 44 of its *Bulletin* was dedicated to him.

Mr. Hedrick was married to Helen Breedon Seidenstricker on October 21, 1901, who, with eight children and one adopted daughter, survives him. Their home in Los Angeles has long been a welcome center for various social activities.

The American people and humanity generally suffer a great loss in the death of this man. Although always tremendously active, he never failed to give time and sympathetic interest to the affairs of a host of friends.

VIRGIL SNYDER

BROWN UNIVERSITY

RECENT DEATHS

DAVID GROSH THOMPSON, geologist of the U. S. Geological Survey, known for his work on the development of water supplies from underground sources, died on February 19 at the age of fifty-four years.

DR. FRANCIS J. POND, professor of chemistry and director of the Morton Memorial Chemistry Laboratory of the Stevens Institute of Technology, consultant in chemical research, died on February 18 at the age of seventy-one years.

LIEUTENANT COMMANDER FRANK K. MOSS, of the United States Naval Reserve, died on February 16. He was forty-four years old. Since 1933 he had been research physicist in the lighting research laboratory of the General Electric Company at Nela Park, Cleveland.

Nature reports the death of Sir Arbuthnot Lane, the well-known surgeon, on January 16, aged eighty-six years, and of Sir Henry Maybury, president in 1933 of the British Institution of Civil Engineers, on January 7, aged seventy-eight years.

DR. C. C. FARR, F.R.S., emeritus professor of physics at Canterbury College, Christchurch, the University of New Zealand, died on January 27 in his seventy-seventh year.

THE death is announced of Dr. David Hilbert, professor of mathematics at the University of Göttingen. He was eighty-one years old.

SCIENTIFIC EVENTS

POST-WAR FOOD SUPPLIES

IN a report prepared by allied agricultural experts and considered by the British Technical Advisory Committee on Agriculture in London, it is stated that the estimated decline of livestock in enemy-occupied allied countries as a result of lack of feeding-stuffs, requisitioning and slaughter is about 11,000,000 cattle, 3,000,000 horses, 12,000,000 pigs and 11,000,000 sheep. The *Times*, London, points out that the decline constitutes a very serious menace both to post-war food supplies and to the future of European agriculture. Milk production has gone down by more than a third, and meat production by nearly half. Recovery to pre-war numbers of breeding animals will take many years, and the lack of draught animals may be a serious hindrance to cultivation for the first post-war harvest.

Only a small proportion of this huge livestock loss could be made good by the supply of live animals. The first need will be for a policy of conservation of livestock, for the preservation of all animals capable of breeding and for the supply of an equivalent quantity of meat from overseas. At the same time feeding-stuffs will be needed, as well as veterinary measures to check the spread of epidemics among livestock already weakened by undernourishment. In countries where the numbers of draught animals have declined below the minimum needed for cultivation it may be necessary to replace them with tractors.

In connection with this last problem, the Technical Advisory Committee has taken note of the probable need to introduce mechanical cultivation into countries where few agricultural engineers or mechanics are to be found. The committee has therefore recommended provision for the training of allied nationals in Britain, such training to include tractor-driving, maintenance and the organization of mechanized services in agriculture generally.

MATHEMATICAL TABLES

A NEW quarterly publication of the Division of Physical Sciences of the National Research Council, "Mathematical Tables and Aids to Computation," edited on behalf of the committee on mathematical tables and aids to computation by the chairman, Raymond Clare Archibald, will serve as a clearing-house for information concerning mathematical tables and other aids to computation.

Tools for computation have been greatly multiplied, especially during the past decade. These tools, or accounts of them, are to be found in the international range of book, pamphlet and periodical publication, not only in the fields of pure mathematics, physics, statistics, astronomy and navigation, but also in such fields as chemistry, engineering, geodesy, geology, physiology, economics and psychology. An attempt will be made to guide varied types of inquiries to such material.

The chief parts of each issue will normally be devoted to Articles, Recent Mathematical Tables (critical reviews), Mathematical Tables—Errata, Unpublished Mathematical Tables, Mechanical Aids to Computation, Notes, Queries, Queries-Replies.

It is hoped that through this quarterly workers in different fields may become conversant with published and unpublished mathematical tabular material and that the critical surveys of all tables in special fields may be especially useful. The corrections of errata in standard tables of importance and the publication of proofs of unreliability of other well-known tables ought also to save much misdirected effort. It is the belief of some members of the committee that such a publication may contribute to the war effort and become a permanent record of importance.

CONFERENCE ON ATTAINING MAXIMUM EFFECTIVENESS OF INSECTICIDES AND FUNGICIDES

A CONFERENCE was held in Columbus, Ohio, on February 14 to discuss the possibilities of stretching supplies of war-short fungicides, such as copper and mercury, and scarce insecticides, such as rotenone and arsenicals, by reducing dosages and increasing the efficiency of applying the unavoidably small amounts. Data on the subject were obtained by entomologists and phytopathologists in a number of state and federal experiment stations during the past season. The conference was scheduled originally for the New York meetings of the American Association for the Advancement of Science as part of the program of the American Association of Economic Entomologists, the American Phytopathological Society and the Biometrics Section of the American Statistical Association. It was held at this time so that the conclusions would be available before the coming growing season, and participants could attend in conjunction with committee meetings of one of the constituent societies and related groups, which were held in Columbus on the preceding two days. The conference was aided by the cooperation of the National Research Council and several state and federal agencies.

More than 50 attended the conference, and many interesting phases of the relationship between dosage and pest control were discussed. Particular emphasis was placed on the utilization of the dosage-response technique in comparing (1) two or more materials or mixtures of materials and (2) different methods of application of the same materials. Suggestions for designing experiments to utilize dosage-response methods in 1943 are being prepared for distribution to participants in the conference and others who may be interested. A report of the results for 1942 will be issued later when the statistical analyses have been completed. Copies of these reports may be obtained by writing to the chairman of the conference, the undersigned, at Box 1106, New Haven, Connecticut.

C. I. BLISS

RARE CHEMICALS

THE following chemicals are wanted by the National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Dearborn and Federal Streets, Chicago, Ill.:

1. Diethylmonobromogold
2. Paredrine Hydrobromide
3. d-malic acid
4. Glycuronic Acid
5. Ostruthin
6. Methoxycaffeine
7. Glyoxylic Acid
8. Thallium Bromide
9. Thallium Iodide
10. Antimony Triiodide
11. Thymus nucleic acid
12. o-nitrobenzaldehyde
13. p-Naphthylhydrazine hydro-chloride

TECHNICAL AND SCIENTIFIC POSITIONS WITH THE GOVERNMENT

MEN and women are sought to fill positions as technical and scientific aids in the Federal Government. They are needed to do research and testing in the following fields: chemistry, geology, geophysics, mathematics, metallurgy, meteorology, physics and radio. The positions pay from $1,620 to $2,600, plus overtime.

Applicants may qualify through experience or education. For the assistant grade, applications will be accepted from persons who have completed one year of paid experience or a war-training course approved by the U. S. Office of Education. One year of college study, including one course in the option applied for,

is also qualifying. Persons now enrolled in war-training or college courses may apply, subject to completion of the course. For the higher grades successively greater amounts of education or experience are required.

The majority of positions are in Washington, D. C., but some will be filled in other parts of the United States. There are no age limits, and no written test is required. Applications and complete information may be obtained from first- and second-class post offices, from civil service regional offices and from the commission in Washington, D. C. Applications will be accepted at the U. S. Civil Service Commission, Washington, D. C., until the needs at the service have been met.

Trainee positions in technical and scientific work will be filled in Washington, D. C., and vicinity. The salary is $1,440 a year plus overtime, and the only educational requirement is that the applicant must have completed one high-school credit of physics, chemistry, mathematics, biology or general science. There are no options.

Persons using their highest skills in war work are not encouraged to apply. War manpower restrictions on federal appointments are given in Form 3989, posted in first- and second-class post offices.

ATTITUDES OF STATE ACADEMIES TOWARD WARTIME MEETINGS

IN an effort to discover the attitude of other state academies toward meetings during wartime, and possible action regarding election of officers and publication of papers in the event of the cancellation of a meeting, Secretary V. Earl Light, of the Pennsylvania Academy of Science, questioned secretaries of all academies affiliated with the American Association for the Advancement of Science.

Twenty replies have been received to date, the majority of them reporting that meetings will be held this spring. Encouraged both by the nature of these findings and by a canvass of a sampling of its members, the executive committee of the Pennsylvania Academy of Science decided to hold its nineteenth annual meeting in April.

The following academies plan to meet this year: Alabama, Colorado, Wyoming, Illinois, Kansas (seventy-fifth anniversary meeting), Kentucky, Louisiana (one day meeting), Michigan, Missouri, North Carolina, Ohio, Pennsylvania, Texas, Wisconsin and Washington, D. C.

An Indiana Academy meeting is "probable"; Tennessee and Virginia are reported "undecided." Two states listed meetings as doubtful; New Hampshire (did not meet in 1942) and West Virginia. Only three academies replied that meetings definitely would not be held: Mississippi, Northwest and South Carolina.

Secretary R. F. Paton, of the Illinois Academy, expressed what appears to be a general conviction that "state meetings are most important since the national meeting was cancelled."

In the event that no meeting is held, most academies indicated that they would follow the practice of the American Association for the Advancement of Science in retaining present officers. New Hampshire plans to elect new officers by mail ballot.

Continuation of publications may be anticipated on the basis of replies. Mississippi and South Carolina probably will not issue their journals, while West Virginia expects to postpone publication for at least a year. For the first time, several states will accept for publication articles which have not been presented at a meeting of the academy.

The Pennsylvania Academy has shortened its program; it has cancelled its annual banquet and transferred its scheduled meeting from the overcrowded Philadelphia area to more centrally located Harrisburg. The usual submitted papers have been dispensed with, and its program has been organized around reports of state agencies and departments on the role of research in the war and in post-war planning. The meeting of the Pennsylvania Junior Academy of Science has been postponed, but the Senior Academy has undertaken a broad program of assistance for high-school science clubs.

CHARLES E. MOHR,
President, Pennsylvania Academy of Science

PACIFIC DIVISION OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE twenty-seventh annual meeting of the Pacific Division of the American Association for the Advancement of Science will be held from June 14 to 19 at Oregon State College. The executive committee met recently to consider the plans tentatively formulated during the past six months for the Corvallis meeting. Attention was given to the difficulties which have arisen during the past year in respect to the holding of conferences in general. After careful examination of the whole problem, and in the light of communications received from the Office of Defense Transportation, the Science Committee of the National Resources Planning Board and other organizations and individuals who have devoted thought to this problem, the executive committee voted unanimously to approve the holding of the meeting and to confirm the arrangements which have been entered into to date. Of three general addresses which will be presented in the course

of the meeting, one will be by Professor Linus Pauling, president of the Pacific Division, on "The Relation of Molecular Structure to Biology and Medicine," and the second by Professor Agnes Fay Morgan, of the University of California, who will speak on the subject of "Nutrition in Wartime." Arrangements for the third address are incomplete.

The morning of Tuesday, June 15, will be devoted to a general symposium on the subject "A Century of Science in the Pacific Northwest," in which three papers will be contributed in the fields of agriculture, forestry and engineering.

A session devoted to reviews of current research will constitute the program of Tuesday afternoon. Four speakers will outline recent advances in the fields of genetics, botany, zoology and mathematics.

The following affiliated organizations have indicated their intention to participate in the meeting:

Organization	*Secretary or Program Chairman*
American Association of Economic Entomologists, Pacific Coast Branch	Roy E. Campbell, Alhambra, California
American Association of Physics Teachers	C. J. Overbeck, Northwestern University
American Association of Physics Teachers, Oregon Section	E. H. Collins, University of Oregon
American Chemical Society, Pacific Intersectional Division	E. C. Gilbert, Dept. of Chemistry, Oregon State College, Corvallis
American Geophysical Union Section on Hydrology	J. C. Stevens, Spalding Building, Portland, Oregon
American Mathematical Society	A. D. Michal, California Institute of Technology, Pasadena
American Phytopathological Society, Pacific Division	C. E. Yarwood, Division of Plant Pathology, University of California at Berkeley
American Society of Plant Physiologists, Western Section	D. I. Arnon, University of California at Berkeley
Association of Pacific Coast Geographers	J. W. Hoover, 1224 S. McAllister Avenue, Tempe, Arizona
Botanical Society of America, Pacific Section	Bassett Maguire, Utah State Agricultural College, Logan
California Academy of Sciences, Committee on Natural Illumination	O. P. Jenkins, Division of Mines, State of California, San Francisco
Ecological Society of America, Western Section	H. de Forest, University of Southern California, Los Angeles
Oceanographic Society of the Pacific	C. L. Utterback, University of Washington, Seattle
Oregon Psychological Association	Allen East, University of Oregon Medical School, Portland
Pacific Northwest Bird and Mammal Society	Earl J. Larrison, University of Washington, Seattle
Society of American Foresters, Northern California Section	Roy G. Wagner, 930 Phelan Building, San Francisco, California
Society for Experimental Biology and Medicine, Pacific Coast Branch	Dr. Rosalind Wulzen, Department of Zoology, Oregon State College
Western Interstate Snow Survey Conference, Pacific Division	R. A. Work, P.O. Box 1149, Medford, Oregon
Western Psychological Association	Othniel R. Chambers, Oregon State College
Western Society of Soil Science	W. P. Martin, University of Arizona

The program for the Corvallis meeting will be prepared during the month of May. Copies will be available at registration headquarters and will be mailed on request to members of participating societies. Each person planning to present a paper before one of the societies should communicate the title to the secretary or program chairman not later than April 15. In case the author is a member of a society which will not be participating in the Corvallis meeting, the title may be sent to the secretary of a closely related participating organization. Titles should be accompanied by abstracts of not over 200 words.

SCIENTIFIC NOTES AND NEWS

AT the graduation ceremonies of the University of Buffalo, the chancellor's medal, awarded annually by the university council for outstanding achievement, was presented to Dr. George W. Thorn, Hersey professor of the theory and practice of physic in the Harvard Medical School and physician in chief of Peter Bent Brigham Hospital, Boston.

DR. ARTHUR W. BINGHAM, chairman of the committee on maternal welfare of the Medical Society of New Jersey, has been presented by the Academy of Medicine of Northern New Jersey with the fourth Dr. Edward J. Ill award—a bronze plaque given to a North Jersey physician by the academy "at such time as it deems it wise, who merits it for extraordinary service as a physician and a citizen."

THE American Association of Economic Entomologists has designated as an outstanding accomplishment of 1942 researches on the chemical properties and the insecticidal value of so-called summer-type oil sprays when used against the eggs of the codling moth, the Oriental fruit moth and bud moth conducted by Dr. P. J. Chapman, entomologist, and G. W. Pearce and Dr. A. W. Avens, chemists of the New York State Agricultural Experiment Station at Geneva. The work is part of a comprehensive research program.

THE 1943 award in the annual nation-wide com-

petition sponsored by the Chicago Dental Society, for original research related to dental problems, was presented to Dr. Harry H. Shapiro and Dr. Raymond C. Truex, both assistant professors of anatomy at the College of Physicians and Surgeons, Columbia University. The prize-winning essay, entitled "The Temporomandibular Joint and Auditory Function," was read on February 22 at the annual meeting of the society in Chicago.

Nature reports that the medal of the British Institute of Metals has been awarded to Dr. Harold Moore for "outstanding services to non-ferrous metallurgy." Dr. Moore has been director of the British Non-Ferrous Metals Research Association since 1932. The medal, which is offered to the council of the institute by the Mond Nickel Company, Ltd., for award annually, is of platinum. Previous recipients have been Sir William Bragg, Sir Harold Carpenter, Dr. Paul Merica, Dr. C. H. Desch and Sir W. Murray Morrison. It was presented to Dr. Moore at the annual general meeting held in London on March 3.

AT the one hundred and twenty-first annual commencement of the Philadelphia College of Pharmacy and Science on February 24 the degree of doctor of science was conferred on Dr. William A. Feirer, director of the medical research laboratories of Sharp and Dohme, Inc., and on Dr. Harriet L. Hartley, of the Department of Public Health of the City of Philadelphia.

THE doctorate of science of Rollins College was conferred at the Founders' Day convocation exercises on George Howard Opdyke, of Hartford, Conn., mining engineer and petroleum geologist.

DR. H. JUSTIN RODDY, since 1926 professor of geology and executive curator of the Museum of Franklin and Marshall College, has been appointed professor and curator emeritus.

ACCORDING to *Nature,* the Committee of the Athenaeum, London, has elected the following, under the provisions of Rule II of the club, which empowers the annual election by the committee of a certain number of persons of distinguished eminence in science, literature or the arts, or for their public services: Professor Emile Cammaerts, professor of Belgian studies and institutions in the University of London; Admiral Sir Andrew Cunningham and Professor W. N. Haworth, professor of chemistry in the University of Birmingham.

DR. EUGENE MARKLEY LANDIS, professor of internal medicine at the University of Virginia, Charlottesville, has been appointed, effective on July 1, George Higginson professor of physiology at the Harvard Medical School, Boston, to succeed Dr. Walter B. Cannon, who recently retired.

DR. THOMAS BIGELOW CRUMPLER has been appointed head of the department of chemistry in the College of Arts and Sciences of Tulane University. He has been on the teaching staff at Tulane since 1937. Dr. Worden Waring has been appointed to an assistantprofessorship and Dr. Walter James Horton, Dr. Kurt Kraus and Dr. Billie Shive have been appointed instructors.

DR. ERNEST GARDNER, instructor in anatomy at Stanford University, has been appointed assistant professor of anatomy at the School of Medicine of the University of Southern California. Dr. Arnold Lazarow, formerly of the department of anatomy of the University of Chicago, is now research assistant in the department of anatomy of the University of Southern California.

DR. JOHN ALFRED RYLE, regius professor of physic at the University of Cambridge and physician extraordinary to the King of England, has been elected professor of social medicine at the University of Oxford.

DR. KENNETH A. BARTLETT, acting director of the Puerto Rico Federal Experiment Station since November, 1941, has been appointed director.

R. E. ZIMMERMAN, vice-president of the U. S. Steel Corporation, has been elected a member of the Board of Trustees of Franklin and Marshall College.

DR. LEWIS HILL WEED, director of the School of Medicine of the Johns Hopkins University, has been made chairman of the Medical and Health Advisory Committee of the American Red Cross. Dr. Weed has been chairman of the Division of Medical Sciences of the National Research Council since 1939.

DR. A. C. DAHLBERG, head of the dairy division of the New York State Experiment Station at Geneva, has been granted leave of absence by Cornell University in order to carry out a special mission in Central America and the northern part of South America for the U. S. Department of Agriculture and the Office of the Counsellor on Inter-American Affairs of the State Department. He will make available to Latin America the knowledge and experience available in this country on milk processing and dairy manufactures. His work will consist of surveys of the dairy industries of the countries he visits and of counsel with government and educational officials, farmers and dairy plant operators as an aid to stimulating milk production, increasing dairy manufactures and improving dairy practices. Dr. R. E. Hodgson, formerly of the Washington State College and now with

the U. S. Department of Agriculture, is accompanying Dr. Dahlberg. Most of the travel will be by plane.

THE nineteenth Ludvig Hektoen Lecture of the Frank Billings Foundation will be delivered by Dr. Lloyd F. Craver, New York, on March 26, under the auspices of the Institute of Medicine of Chicago. The subject of the lecture will be "The Diagnostic Problems of Early Cancer."

DR. ALFRED BLALOCK, professor of surgery at the Johns Hopkins University School of Medicine and director of the department of surgery at the Johns Hopkins Hospital, will give on March 11 the tenth E. Starr Judd Lecture at the University of Minnesota Medical School. He will speak on traumatic shock with particular reference to war injuries.

DR. RICHARD C. TOLMAN, professor of physical chemistry and mathematical physics at the California Institute of Technology and dean of the Graduate School, gave a lecture on "Physical Science and Philosophy" at the meeting on February 27 of the Philosophical Society of Washington.

PROFESSOR L. C. DUNN, of the department of zoology of Columbia University, gave an illustrated address on "Mistakes in Development in Mice and Men" before the Four-College Genetics Conference at Smith College on February 18. He also spoke to the classes in genetics at Amherst and Smith Colleges.

DR. LAURENCE H. SNYDER, chairman of the department of zoology and entomology of the Ohio State University, addressed the Louisiana State University chapter of Sigma Xi on February 9 on "Heredity and Modern Life." On February 10 he spoke at a meeting of Beta Tau Mu on "The Mutant Gene in Man."

PROFESSOR VERNON L. FRAMPTON, of the department of plant pathology at Cornell University, will deliver a series of lectures during March and April on "Colloid Chemistry" at the National University of Colombia at Bogota. During the past several years he has made a study of the chemistry of viruses causing plant diseases.

DR. MARGARET MEAD, assistant curator of ethnology of the American Museum of Natural History, visited Iowa State College from February 16 to 18. She gave a public lecture on "National Character and International Cooperation" and spoke to various seminars and other groups.

THE annual general meeting of the American Philosophical Society will be held on April 22, 23 and 24, beginning at 10 A.M., on Thursday, April 22. The morning, afternoon and evening sessions on Thursday, April 22, will be devoted to a celebration of the two hundredth anniversary of the birth of Thomas Jefferson. Carl Becker will deliver the Penrose Memorial Lecture on Thursday evening, April 22, on Jefferson's political philosophy with especial reference to the present. On Friday evening, April 23, Fiske Kimball will speak on "Jefferson and the Fine Arts." This will be followed by a musical program consisting of selections favored by Jefferson. On Saturday afternoon, April 24, at 2 o'clock there will be an illustrated lecture on "Historic Sites of Old Philadelphia," followed by visits to principal points of interest. The annual dinner on Saturday evening, at the Bellevue-Stratford Hotel, will commemorate the two hundredth anniversary of the proposal by Benjamin Franklin for forming the American Philosophical Society for promoting useful knowledge among the British Plantations in America. The Franklin Medal Lecture will be given on this occasion by Carl Van Doren on "The Beginnings of the American Philosophical Society." The sessions on Friday afternoon and Saturday morning will consist of papers by members and invited guests on various subjects. The annual executive session and election of officers and members will be held on Friday morning, April 23, at 9:30 o'clock.

THE cancellation of the annual meeting of the American Statistical Association in 1942 made it impossible to effect a change of officers by means of the customary election by the membership of the association. At its first meeting in 1943 the board of directors of the association accepted the resignations of the 1942 officers and appointed to the vacant offices the candidates proposed by the nominating committee. The officers of the association for 1943 are: E. A. Goldenweiser, *President;* C. I. Bliss, William G. Cochran, Roy L. Gillett, A. Ford Hinrichs, Walter Mitchell, Jr., Frank M. Surface, Donald B. Woodward and Theodore O. Yntema, *Vice-presidents;* R. L. Funkhouser, *Secretary* and *Treasurer.* Henry B. Arthur, Theodore H. Brown, Simon Kuznets and Alfred J. Lotka were appointed members of the board of directors.

DR. E. BRAUN-MENENDEZ, *Secretary,* and Dr. B. A. Houssay, *President,* of the third Pan American Congress of Endocrinology, have written as follows to Dr. Robert A. Lambert, associate director of the Rockefeller Institute: "This is to let you know that the Executive Committee of the Third Pan-American Congress of Endocrinology has decided to postpone *sine die* the realization of this congress. We wished to give the congress a real importance, but the absence of the lecturers appointed and of many other outstanding scientists would diminish the rank and dignity we think it should have."

THE three hundred and ninety-fifth meeting of the American Mathematical Society will be held at Hunter College on Friday and Saturday, April 23 and 24.

Sessions will begin on Friday morning and continue until noon on Saturday. The following addresses will be given by invitation of the program committee: "Spectral Theory," by Professor Nelson Dunford, of Yale University, on Friday afternoon; and "Absolutely Convergent Trigonometric Sums," by Professor R. H. Cameron, of the Massachusetts Institute of Technology, on Saturday morning.

DISCUSSION

THE TRIPLE POINT OF WATER

IN a survey of ten current text-books on physical chemistry, it was found that in only one of the eight which gave data on the triple point of water was the correct value for the temperature given. The usual value given is +.0075° C, which is that in the International Critical Tables.[1] This is actually the difference between the triple point temperature and the temperature at which ice and pure water are in equilibrium under one atmosphere total pressure. More recently this difference in temperature has been established experimentally[2,3] as 0.0074° C, and it can be calculated from the Clausius-Clapeyron equation of thermodynamics.[3,4] But the equilibrium temperature of ice and pure water at one atmosphere pressure is not zero degrees Centigrade.

In 1927, at the international Seventh General Conference of Weights and Measures, it was agreed that 0° Centigrade be defined as the temperature at which ice and air-saturated water are in equilibrium at one atmosphere total pressure.[5] Saturation of water with air lowers the equilibrium temperature by 0.0024° C.[2,3,4] The total difference in temperature between this as 0° C (on the International Scale defined at this conference) and the triple point is then .0024 + .0074, and the triple point temperature is +0.0098° C (International).[6]

The vapor pressure of the liquid is usually defined as the pressure exerted by the pure vapor in equilibrium with pure liquid when the liquid is under no pressure except that of its own vapor; a similar definition is given for the vapor pressure of the solid. At the triple point, the vapor pressures of liquid and of solid are identical, but they decrease at different rates as the temperature is decreased. Therefore they are not identical at a temperature of 0° C, as most tables imply.[7] Usually, in calculating the vapor pressure of the solid, it is equated to that of the liquid at 0° C, instead of at the triple point.[8,9] There are thus inconsistencies in the values given for the vapor pressures of solid and of liquid near 0° C. The differences are small but appreciable.

The pressure exerted by the vapor in equilibrium with the liquid under various conditions not only changes with temperature, but also changes slightly if an excess pressure is exerted on the liquid phase, and if substances are dissolved in the liquid. The pressure exerted by the vapor in equilibrium with the solid behaves similarly. Liquid and solid water may exist in equilibrium, with equal but varying vapor pressures over a range of conditions, if these conditions are properly varied.

In addition to the triple point, two other equilibria are of interest. Pure liquid and solid are in equilibrium under one atmosphere total pressure at +.0024° C, and air-saturated liquid and solid are in equilibrium under one atmosphere total pressure at 0° C. The vapor pressure will be different in each of these three equilibrium states. The triple point pressure is the vapor pressure of liquid water or of ice (under only its own vapor pressure) at the triple point temperature. The difference between this and the vapor pressure in these other two states may be calculated by considering the variation as made up of the sum of three separate effects.

First, as noted above, the vapor pressures of solid and liquid decrease with a decrease in the temperature. Second, the vapor pressure of a liquid or solid (a condensed phase) is increased if a pressure is exerted on the condensed phase alone and not on the vapor. For example, if air pressure is exerted on a condensed phase, the vapor is not itself compressed since it can mingle freely with the air. This gives an excess pressure on the condensed phase. Third, the dissolving of air in the liquid lowers the vapor pressure of the liquid. We may assume air is insoluble in ice, or at worst that its solubility is so small as to have a negligible effect on the vapor pressure. The first and third effects tend to cancel the second, in our particular examples.

[1] "International Critical Tables," Vol. IV, p. 11. McGraw-Hill, New York, 1928.

[2] H. Moser, *Ann. der Physik*, (5), 1: 341–360, 1929; quoted in references 3 and 4.

[3] J. A. Beattie, T. C. Huang and M. Benedict, *Proc. Amer. Acad. Arts and Sciences*, 72: 137–155, 1938.

[4] N. E. Dorsey, "Properties of Ordinary Water-Substance," p. 604. Reinhold Publishing Corporation, New York, 1940.

[5] G. K. Burgess, *Bur. Standards Jour. Res.*, 1: 635–640, 1928.

[6] See also B. P. Veĭnberg, *Jour. Exptl. Theoret. Phys.* (U.S.S.R.), 9: 106–113, 1939, quoted in *Chemical Abstracts*, 33: 7655, 1939; he selects +0.0099° C as the best value.

[7] *E.g.*, "International Critical Tables," Vol. III, p. 211.

[8] E. W. Washburn, *Monthly Weather Review*, 52: 488–490, 1924; these calculations were made for, and are incorporated in, reference 7.

[9] J. E. Goff, *Heating, Piping and Air Conditioning*, 14: 121–124, 1942. Dr. Goff has recently informed me that this correction was allowed for, although not explicitly stated in his paper.

The changes can be calculated quantitatively from thermodynamic equations, and the values found show that the vapor pressure for the equilibrium system at +.0024° C is 0.0012 mm higher than that at the triple point, and at the 0° equilibrium it is 0.0003 mm higher. For most practical purposes these changes are negligible, and the vapor pressure in any of these three states may be taken as 4.579 mm[7] or 4.581 mm.[10] A recent experimental determination has given the triple point pressure as 4.5867 mm;[11] this is not consistent with other values accepted at present for the vapor pressure of liquid water at temperatures near the triple point.

SUMMARY

(1) A common error in text-books on physical chemistry is pointed out. It is hoped that the correct value for the triple point temperature, +.0098° C, will be given in new books and in succeeding editions of the books surveyed above.

(2) Inconsistencies in the vapor pressure values for ice and for liquid water near 0° C are pointed out.

(3) The equilibrium vapor pressures for ice and liquid water under two different sets of equilibrium conditions are compared with the triple point pressure.

WORDEN WARING

TULANE UNIVERSITY

PALEOBOTANY IN INDIA

I HAVE just received from Professor Sahni of the University of Lucknow, India, a Progress Report on Paleobotany in India, at the head of which appears the following statement:

"We mourn the death of Albert Charles Seward (April 11, 1941). Doyen of Paleobotanists, whose noble personality, no less than his vast learning, was a fountainhead of inspiration to the Indian school of paleobotany."

Those of us who knew Sir Albert Seward as Master of Downing College, Cambridge, had long marvelled at his ability to carry on administrative and teaching work, along with research in paleobotany, and had noted his power of inspiring and fostering research among those who were so fortunate as to come under his direction. But at the present time, we are particularly concerned to note what he was able to do for India; mainly, it appears through the influence of his ardent disciple Sahni. With this source of inspiration, a school of Indian paleobotanists, centering in Lucknow, has developed and for many years their writings have brought to us new information concerning the fossil flora of India. Sahni, in recognition of his work, has been elected a Fellow of the Royal Society.

A paper by Sahni, which accompanies the Report, has to do with the beautifully preserved petrified remains of *Azolla,* showing all the minute details of structure. "The first and most striking fact concerning this specimen is the great perfection in which it is preserved. This helps us to see that in this early Tertiary *Azolla,* which is definitely the oldest known species of the genus, some of the most intimate details of the structure, and the way in which the massulae become anchored to the megaspore, are identical with those found in modern species. Considering that this plant lived about 60–70 million years ago it affords an impressive example of the persistence through the ages of a highly specialized type of behavior during the reproductive phase of the life-history of a genus."

The Oriental mind, for ages developing according to what seemed to be its peculiar genius, now shows its ability to take on the qualities of western culture, for good and for evil. It appears that scientific men such as Seward may promote the good influences, and cause the oriental workers to discover and develop their innate abilities. In such ways scientific research may serve the cause of civilization.

T. D. A. COCKERELL

CITRUS EXPERIMENT STATION,
RIVERSIDE, CALIFORNIA,

SCIENTIFIC BOOKS

CYTOPLASM OF THE PLANT CELL

The Cytoplasm of the Plant Cell. By A. GUILLIERMOND. Authorized translation from the unpublished French manuscript by Lenette R. Atkinson. Foreword by Professor William Seifriz. Waltham, Mass.: the Chronica Botanica Company. New York City: G. E. Stechert and Company. 247 pp. 152 figs. 1941. $4.75.

THIS is Volume VI in a new series of plant science books edited by Dr. F. Verdoorn. It is fortunate that the war has not prevented its translation by Mrs. Atkinson and publication in its present form, for it is a critical survey of all that has been done with regard to chondriosomes, vacuoles and various other structures in the cytoplasm of plant cells, by one who has made many of the most important contributions in this field.

One of the difficulties in the study of protoplasm is that it is usually divided into such small compartments, the cells, which are sensitive even to minor

[10] N. S. Osborne and C. H. Meyers, *Bur. Standards Jour. Res.,* 13: 1–20, 1934.

[11] K. Prytz, *Kgl. Danske Videnskab. Selskab. Math.-fys. Medd.,* 11: 7–46, 1931; quoted in *Chemical Abstracts,* 26: 627, 1932, and in reference 4 pages 563 and 575.

manipulation and *intra vitam* stains. Another is that in order to study protoplasmic structures they must usually be subjected to some stain, even if they are not killed, and the mere process of mounting for microscopic examination alters the oxygen supply and various other conditions. Guilliermond is fully conscious of all this, and his interpretations always allow for the possibility of some slight change from the healthy living condition even under the most careful treatment. In the twenty chapters of this volume his critical faculty is always on the alert to point out that the obvious interpretation is not necessarily the correct one or the only one. The general result is a solid body of well-documented material and conclusions, which will be of much value to all who are interested in the experimental study of protoplasm and the structures contained in the cytoplasm of plant cells.

The introductory chapters deal with the physical and chemical constitution of protoplasm, in which it is pointed out, for instance, that the viscosity ranges from 3 times to 10,000 times that of water and any isolated bit of cytoplasm forms a membrane about itself according to the law that molecules which lower the surface tension tend to accumulate in the peripheral layer. Much use is made of basic vital stains, such as Nile blue, cresyl blue and neutral red, while chrysoidine, probably because it is readily dissolved in lipides, stains clearly both cytoplasm and nucleus in cells which still show cytoplasmic streaming. But if growth is to continue, the vital dye is first accumulated in the vacuoles. In a chapter on the physical chemistry of protoplasm, microdissection and the coacervates of Bungenberg de Jong are among the topics considered.

In the chapter on plastids and the grana which are seen in some types of plastids, while no final opinion regarding their structurue is reached, plastids are regarded as probably composed of small lipide discs containing cholorophyll and embedded in a hydrophilic stroma. Five chapters are devoted to the chondriosomes and their relation to plastids. The duality of the chondriome is recognized and the author concludes on good grounds that plastids and chondriosomes are two categories of organelles which are permanently found in every cell of green plants, both showing all the characteristics of the chondriosomes in animal cells. The fact that the chondriosomes undergo vesiculation under some conditions leads to the conclusion that they also are coacervates.

Other chapters are concerned with the vacuoles, their vital staining, origin and development; and their transformations are fully illustrated in flowering plants, fungi and algae. They arise *de novo* in the cell and are believed to form through the separation from the cytoplasm of colloids having a stronger capacity for taking up water. The canaliculi of young plant cells are transformed into vacuoles, but a consideration of the evidence leads to the conclusion that there is no Golgi apparatus in plant cells.

This book should stimulate the study of the extreme complexity in morphological constitution of the cytoplasm, a colloidal system in which the chondriosomes, plastids and vacuoles constitute distinct phases. It adheres rather closely to the plant cell, but after all, that was the aim of the book.

One may agree with Dr. Seifriz, who has written the foreword, in being impressed with the thoroughness and the condensation with which the book has been written. The index of authors and of plant and animal names hardly compensates for the lack of any index of topics, and the frequent lack of dates in references to authors' papers will make some of them difficult to identify.

R. RUGGLES GATES

WOODS HOLE, MASS.

SOCIETIES AND MEETINGS

THE AMERICAN SOCIETY OF TROPICAL MEDICINE

THE American Society of Tropical Medicine, meeting conjointly with the Southern Medical Association, the National Malaria Society and the American Academy of Tropical Medicine, held its thirty-eighth annual meeting in Richmond, Virginia, on November 10, 11 and 12, 1942.

One of the outstanding features of the scientific session was the seventh Charles Franklin Craig lecture on tropical medicine, entitled, "The Importance of Tropical Medicine in the Armed Forces," by Rear Admiral Ross T. McIntire, U. S. Navy, Office of the Surgeon General, Washington, D. C.

A second highlight of the meeting was a symposium on "Tropical Medicine and the Medical School Curriculum," at which Dr. H. E. Meleney of New York presided. Dr. Paul Russell, Lieutenant Colonel, Washington, D. C., discussed the "Military Need," and Dr. Jean A. Curran, Brooklyn, N. Y., discussed "Finding a Place in the Medical Curriculum." In the absence of Commander M. E. Lapham, Washington, D. C., Dr. Meleney discussed the "Civilian Needs," as well as his own contribution, "Recent Progress." This symposium stressed the fact that there is a definite need for tropical medicine to-day in our medical school curriculum. A two-hour session was devoted to discussing this subject with fifteen

members of the Army, Navy and teaching profession participating, so that each group could learn the needs and difficulties of the other.

There was a record attendance at the annual luncheon of the society. The president, Dr. E. C. Faust, New Orleans, La., gave his presidential address on "Horizons of American Tropical Medicine." The society, for the first time in its history, honored individuals outside of the United States. The Walter Reed Medals of the society were given to two individuals from South and Central American countries. The first was presented to the Brazilian Government through its Minister of Education and Public Health, Dr. Gustavo Capanema, for outstanding work in eradicating *Anopheles gambiae* from Brazil. In the absence of Dr. Capanema, Dr. Mario Kroeff, director of National Council Research, received the award. The second medal was awarded to Dr. Carlos J. Finlay (posthumously) for pioneer work in yellow fever. Due to the illness of Dr. Finlay's son, Dr. Carlos E. Finlay, the medal was received for him by Dr. Domingo Ramos, director of the Finlay Institute, Havana, Cuba.

A round-table discussion entitled, "Malaria Therapy During the Present Emergency," closed the scientific session of the society. Dr. Herbert C. Clark, of Panama, presided, with Lieutenant Commander C. M. Wassell, Hollywood, California, and Dr. R. B. Watson, Memphis, Tennessee, participating. Dr. Clark discussed primarily the efficiency of totaquine as compared with quinine.

The American Academy of Tropical Medicine held its annual dinner, with Colonel R. P. Strong, of Washington, serving as toastmaster. Dr. W. C. Clark delivered his presidential address entitled "Some Impressions of Medical Practice in the Tropics."

The hospitality group met informally in the Jefferson Room of the Jefferson Hotel upon adjournment of the afternoon scientific sessions. In addition to the closer relationship between members and their guests, these meetings provided opportunities for brief discussions on currently vital topics. The first, by Dr. R. E. Dyer, was entitled "The Present Status of Typhus Vaccination." At the second gathering, Colonel George Lull, head of personnel in the Medical Division of the Army, discussed some of the problems associated with his office. These gatherings were again well attended and thoroughly enjoyed by the membership.

JOSEPH S. D'ANTONI,
Secretary-Treasurer

TENNESSEE ACADEMY OF SCIENCE

THE fifty-first meeting of the Tennessee Academy of Science was held at Vanderbilt University, Nashville, on November 27 and 28. A general session of the academy was held on Friday morning, November 27, with sectional meetings in mathematics, chemistry, geology and botany during the afternoon. A special session, new to the academy meetings, was held on Saturday, November 28. This new session was composed of a symposium on the teaching of the sciences under the chairmanship of Dr. A. J. Sharp, Department of Botany, University of Tennessee, and a Junior Science meeting with exhibits and demonstrations from the schools of central Tennessee. The Junior Science session was directed by Dr. Frances R. Bottum, of George Peabody College for Teachers, Nashville. It has been proposed that a junior section of the academy be formed, extending interest in the sciences in the schools, and Edwin D. Schreiber, of the Tennessee Industrial School, was chosen as chairman of this section.

At the academy dinner on November 27, Dr. D. M. Brown, professor of biology, East Tennessee State Teachers College, presented an address as the retiring president. A word of welcome was extended to the academy by Dr. Philip G. Davidson, dean of the Graduate School, Vanderbilt University.

The new officers of the academy for 1943 are Dr. C. S. Shoup, associate professor of biology, Vanderbilt University, *President,* and Dr. Edward McCrady, Jr., professor of biology, University of the South, Sewanee, Tenn., *Vice-president.* Dr. Kendell E. Born, Tennessee Division of Geology, Nashville, was reelected *Secretary-Treasurer,* and Dr. J. M. Shaver, of George Peabody College, Nashville, was reelected as *Editor* of the *Journal of the Tennessee Academy of Science.*

C. S. SHOUP,
President

REPORTS

THE WAR STATUS OF AUSTRALIAN SCIENCE[1]

DURING the past twelve months the problems involved in the rapid expansion of Australian war industry have become more acute, but paralleling the growing unity and determination of the Australian people to defeat the fascists, a number of steps forward in the use of science, for which our association has long been pressing, have been taken. The conferences of Australian scientific workers called by the

[1] A report received by the American Association of Scientific Workers from the head of the Federal Council of the Australian Association of Scientific Workers.

Australian Association of Scientific Workers in the various states of the Commonwealth during the early part of 1942 did, we feel, play an important part in hastening some of these necessary and often long overdue steps. The initiative of scientific workers themselves has greatly assisted in improving the situation.

At the beginning of 1942 the Commonwealth Government appointed a commission of two energetic and capable scientific men (Professor E. Ashby and Dr. J. Vernon) to survey and report on the use being made of Australia's scientific resources in meeting and anticipating war-time problems. Their report revealed serious gaps between the needs of industry and the full use of available scientific knowledge, personnel and equipment.

One of their recommendations which has recently been acted upon is the setting up of an independent, compact and flexible Scientific Liaison Bureau which is charged with the wide responsibility of bridging the gaps between technical problems in the Services, government departments and war industries, and scientific men who can tackle the problems. The bureau is to direct scientific problems to the appropriate laboratory and should be able to advise scientific men as to the most useful contribution they could make to Australia's war needs.

Since early in 1942 there has been a central scientific manpower authority which attempts to allocate the available people to the positions needing them, with proper regard to the priority of important work. It appears likely that the most effective placement of available personnel has been reasonably well attained among physicists, but the same can hardly be said yet of chemists and biologists, though the position is far less chaotic than it was a year ago.

The government has recently introduced an entirely new policy in the training of students in "reserved" faculties in the universities. Students were admitted on a merit basis at the beginning of 1942, but, owing to the financial difficulties facing the majority of promising school pupils, the supply of good students was far short of the needs of the country. As from the beginning of 1943 the government will provide a reasonably adequate living allowance, plus remission of fees, to all students needing such assistance. With admission to the universities established on a merit basis, and with the universities actually inviting promising school pupils to come up, it seems certain that an important step has been taken towards getting the large numbers of graduates of high quality so urgently needed.

There is an acute shortage of physicists in Australia at the present time and means are being explored of ensuring that greater numbers of suitable students are trained. Some use has been made by the services in technical work (*e.g.*, radio) of graduates from other fields of science (*e.g.*, biology), but this use has not been as extensive as in England.

The conferences on "Science in the War Effort" which were convened by our association have led to the setting up, on the initiative of the laboratory personnel concerned, of panels in some sections of industry (*e.g.*, the paint industry). The object of these panels is the pooling and sharing, on a rational basis, of technical knowledge and investigatory work. Such panels are composed solely of technical men in industry and they give promise of being able, in some instances to reduce the hampering effects of trade secrets and of rivalry between firms.

The recent setting up of a food council to plan and direct the country's food production, at a time when the situation was becoming serious, owes something to representations arising from our conferences. At first the food council had insufficient scientific personnel and has not, even yet, sufficiently wide powers.

The association has always recognized that the inadequate salaries and unsatisfactory conditions of work sometimes found among the scientific staffs of smaller firms, particularly among chemists, is not only unwelcome to those immediately concerned and to the scientific profession, but has a bad effect on the application of science to the needs of society and to the war effort. In Australia, one way of remedying such conditions is through the arbitration courts or their conciliation officers. The Australian Association of Scientific Workers is, therefore, considering the question of taking a decision among its members as to the desirability of registering the association with the arbitration court. It appears that many members favor such a step. During the early years of its growth, since its inception in 1939, the association has not done a great deal directly to safeguard and improve the status of its members and it is thought that registration would enable more to be done in that direction.

The Australian Association of Scientific Workers is most anxious to maintain close touch with the Associations of Scientific Workers in Great Britain, the United States and New Zealand, and with the scientific bodies in the Soviet Union. It is felt that facilities should be provided for the free interchange between Allied countries of scientific information needed in war work. To this end, representations have recently been made to the Commonwealth Government asking that scientific liaison services between Australia and both the United States and the Soviet Union should be extended and improved.

For the Federal Council, Australian Association of Scientific Workers,

F. W. WOOD, *Honorary Secretary*

SPECIAL ARTICLES

MACROMOLECULAR COMPONENTS OF NORMAL EMBRYONIC AND ADULT BRAIN TISSUE[1]

ULTRACENTRIFUGAL studies on plant[2] and animal tissues[3] have resulted in the demonstration in healthy organisms of constituents with high sedimentation constants. Recently, a material with a sedimentation constant of $S_{20} = 73.8 \times 10^{-13}$ has been obtained from extracts of chick embryo body tissue, and analyses have shown it to be a lipoprotein complex containing nucleic acid of the ribose type.[4] The frequency with which these components have been encountered and the high concentrations of them occasionally observed indicate not only a wide distribution but also a role of importance in the physiological processes of healthy tissues. In the work described here the question of distribution has been investigated further in studies on brain tissues from man and certain animals.

The studies were made on the whole brain tissue of man, the rabbit and the chick. Both embryonic and adult tissues were examined by procedures similar to those used in isolation of the normal component of the chick embryo body.[4] Fresh tissue was chilled and quickly ground either with sand in a Ten Broeck grinder or in the Waring Blendor. The mince was extracted in 20 per cent. suspension in distilled water for 48 hours at 5 to 8° C. After clarification with the angle centrifuge, the extract was filtered with celite and subjected to 1 or 2 cycles of ultracentrifugation at 67,000 g for 30 minutes. The resulting pellets were dissolved and stored in distilled water.

Two human embryos were studied. The brain from one of these, crown-rump measurement 16.5 cm, weighed 41 gm. From the extract of the cerebral tissue clear gel-like pellets were obtained representing 0.17 mg of nitrogen per gram of initial brain tissue. Solutions of the pellets in concentrations of 0.45 to 0.55 mg N per cc examined in the analytical ultracentrifuge showed sharp sedimenting boundaries indicative of considerable homogeneity. No light-absorbing material was seen above the boundary but beneath it there was present some material which sedimented more quickly than the component giving the sharp boundary. The sedimentation velocity in water was 70.8×10^{-13}. A similar component seen in the second embryo of about the same age gave a sedimentation velocity of 67.5×10^{-13}. Partial elementary analysis showed a composition of N, 12.7; C, 51.4; and P, 2.81 per cent. The density by pyknometer measurement was 1.42. The Millon and biuret tests were positive, and the glyoxylic acid test was weakly positive after 20 minutes. Bial's test following hydrolysis was negative. The Feulgen test was positive and so, too, was the diphenylamine reaction. These results indicate a material essentially protein in nature, possibly associated with a small quantity of fat and containing nucleic acid of the desoxypentose type.

Similar experiments with 4 batches of brain from chick embryos of 14 to 20 days incubation resulted in the purification of a component showing very sharp boundaries with a sedimentation velocity in water of 67.5×10^{-13}. The sedimentation constant in 0.005 M borate buffer, pH 7.2, was 75.2×10^{-13}. The constitution of this component was wholly different from that of human embryo brain but somewhat similar, though not identical, to the chick embryo body component.[4] The carbon content was 50.9, nitrogen 11.3 and phosphorus 2.9 per cent. Bial's test in this instance was strongly positive and the diphenylamine test dubiously positive, indicating a further resemblance of this brain component to that of the body tissue in the presence of ribonucleic acid. The yield was 0.1 mg N per gram of brain.

Experiments with the brain of rabbit embryos yielded a constituent giving good sedimentation diagrams and a sedimentation velocity in water of 68.9×10^{-13}.

Examinations of adult brain from man, chick and rabbit resulted in all cases in preparations showing very diffuse sedimentation diagrams under the same ultracentrifugal conditions giving sharp boundaries with embryo material. The sedimentation velocity of the adult brain material was of the same magnitude as that from embryo tissue. This finding indicated great heterogeneity with respect to particle size. Another striking difference between the embryo and adult was the yield of product which was approximately 5 times greater for the embryo than for the adult. Electron micrographs of the materials from human and chick embryo brain showed rounded images approximately 18 mμ in diameter for both. The images appeared uniform in size and no internal structure was visible.

Thus far the components of normal tissues have been encountered chiefly as complicating factors in the purification of viruses such as those of certain plant diseases and the agent of equine encephalomyelitis.[5] Recent studies[6] on poliomyelitis have revealed in diseased cord and medulla of monkeys a

[1] This work was aided by the Dorothy Beard Research Fund and by a grant from Lederle Laboratories, Inc., Pearl River, N. Y.

[2] W. C. Price and R. W. G. Wyckoff, *Phytopathology*, 29: 83, 1939.

[3] R. W. Glaser and R. W. G. Wyckoff, *Proc. Soc. Exp. Biol. and Med.*, 37: 503, 1937.

[4] A. R. Taylor, D. G. Sharp, D. Beard and J. W. Beard, *Jour. Infect. Dis.*, 71: 110, 1942.

[5] A. R. Taylor, D. G. Sharp, D. Beard and J. W. Beard, *Jour. Infect. Dis.*, in press.

[6] H. S. Loring and C. E. Schwerdt, *Jour. Exp. Med.*, 75: 395, 1942.

material with a sedimentation constant of 62×10^{-13}, a value essentially the same as that obtained with normal brain tissue here. The components isolated in the present work exhibited evidence of high homogeneity in the analytical ultracentrifuge. Despite the similarity of the sedimentation velocity values, the various components, including the material of chick embryo body,[4] differed constitutionally, indicating not only species but organ variation. In addition there was variation associated with age. The results suggest that further study of the normal tissue components may be of significance not only in relation to physiological processes but possibly in the investigation of non-infectious pathological processes such as neoplasms. This is supported by the results of preliminary studies now being made in this laboratory with certain brain tumors of man.

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THE CONVERSION OF DESOXYCORTICOSTERONE TO PREGNANDIOL-3 (α), 20 (α)[1, 2]

THE conversion of desoxycorticosterone acetate to pregnandiol glucuronidate in a normal man was claimed by Cuyler, Ashley and Hamblen.[4] The evidence was based on two isolations of pregnandiol glucuronidate, one m.p. 240° C and the other m.p. 261° C. The melting points of both compounds were low as compared to the melting point for pregnandiol glucuronide (268–271° C) reported by Venning and Browne.[5] No evidence for the identity of the compounds was presented in addition to these melting point determinations. In a second communication Cuyler, Hirst, Powers and Hamblen[6] were unable to reproduce their original results. In the course of a study of the metabolism of desoxycorticosterone and other adrenal cortical steroids in the chimpanzee and human, we have demonstrated the conversion of desoxycorticosterone to pregnandiol-3 (α), 20 (α) in the ovariectomized chimpanzee.

A total of three grams of desoxycorticosterone acetate[3] was administered orally over a period of 15 days. The hormone was administered once daily in doses of 200 mg. Urine was collected for the 15-day period during hormone administration and for the following three days. A total of 14.9 liters of urine was collected. Fifteen cc of concentrated hydrochloric acid and 25 cc of carbon tetrachloride were added to each 100 cc of urine. Hydrolysis and extraction were carried out simultaneously for a period of 8 hours. The carbon tetrachloride was separated and an additional quantity of fresh carbon tetrachloride added and the extraction repeated. The material soluble in carbon tetrachloride was separated into two fractions by means of 10 per cent. sodium hydroxide; one, the fraction containing the neutral compounds, and the other the fraction containing the acidic and phenolic compounds. By means of the Girard-Sandulesco ketone reagent, trimethylacethydrazide ammonium chloride and succinic acid anhydride the total neutral compounds were separated into four fractions: the ketonic-hydroxy, ketonic-nonhydroxy, nonketonic hydroxy and nonketonic-nonhydroxy fractions.

The nonketonic-hydroxy compounds were further separated with digitonin into fractions containing the soluble and insoluble digitonides, respectively. A colorimetric assay of the former fraction indicated 455 mg pregnandiol equivalent.[7] It was adsorbed on a column (10 × 190 mm) of Brockmann's aluminum oxide from a solution of benzene. The column was eluted with progressively increasing concentrations of ethanol in benzene ranging from pure benzene to 16 per cent. ethanol in benzene. The fraction eluted by 1 per cent. ethanol in benzene yielded a crystalline material which assayed 125 mg of pregnandiol equivalent. The material after recrystalizing three times from aqueous ethanol yielded 45 mg of a compound which melted at 228–229° C.[8] A mixture of this compound with an authentic sample of pregnandiol-3 (α), 20 (α), m.p. 229–231° C, melted at 229–230° C. The diacetate melted at 175–176° C and when mixed with pregnandiol-3 (α), 20 (α) diacetate, m.p. 174–175° C, the mixture melted at 174–175° C.

After combining the mother liquors and rechromatagraphing the crude compounds an additional quantity of 34 mg of pregnandiol-3 (α), 20 (α) was isolated. Thus the total quantity of pregnandiol-3 (α), 20 (α) recovered from 3 grams of desoxycorticosterone acetate totaled 79 mg, indicating a conversion of 3 per cent. In a second experiment when 1.2 grams of desoxycorticosterone acetate was administered to the same ovariectomized chimpanzee, 12 mg of pregnandiol-3 (α), 20 (α) were recovered in the urine. This represented a conversion of 2 per cent.

[1] Supported in part by the Josiah Macy, Jr. Foundation. Accepted for publication in SCIENCE, November 14, 1942.

[2] From the Brush Foundation and Department of Biochemistry, Western Reserve University School of Medicine and the Department of Medicine, Lakeside Hospital, Cleveland, Ohio.

[3] The desoxycorticosterone acetate was kindly supplied by the Ciba Pharmaceutical Products Inc. under the trade name of Percorten.

[4] W. K. Cuyler, C. Ashley and E. C. Hamblen, *Endocrinology*, 27: 177, 1940.

[5] E. M. Venning and J. S. L. Browne, *Proc. Soc. Exp. Biol. and Med.*, 34: 792, 1936.

[6] W. K. Cuyler, D. V. Hirst, J. M. Powers and E. C. Hamblen, *Jour. Clin. Endocrinology*, 2: 373, 1942.

[7] N. B. Talbot, R. A. Berman, E. A. MacLocklan and J. K. Wolfe, *Jour. Clin. Endocrinology*, 1: 668, 1941.

[8] Melting points are uncorrected and were determined by means of the Fischer-Johns apparatus.

This conversion of desoxycorticosterone to pregnandiol-3 (α), 20 (α) is unique in the metabolism of the steroid hormones since it is the first instance of the replacement of an hydroxyl group by a hydrogen atom. Thus the primary alcohol group at C-21 in desoxycorticosterone is reduced to the corresponding methyl group in pregnandiol-3 (α), 20 (α).

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

DEVICE FOR THE PREPARATION AND TRANSFER OF OXYGEN-FREE SOLUTIONS[1]

A PROBLEM frequently encountered is the preparation of an air (oxygen)-free solution and its subsequent introduction into an experimental vessel. For example, in the course of spectrophotometric determinations involving solutions of respiratory enzymes and other proteins it is necessary to remove all traces of oxygen and then to transfer the solution to the cell

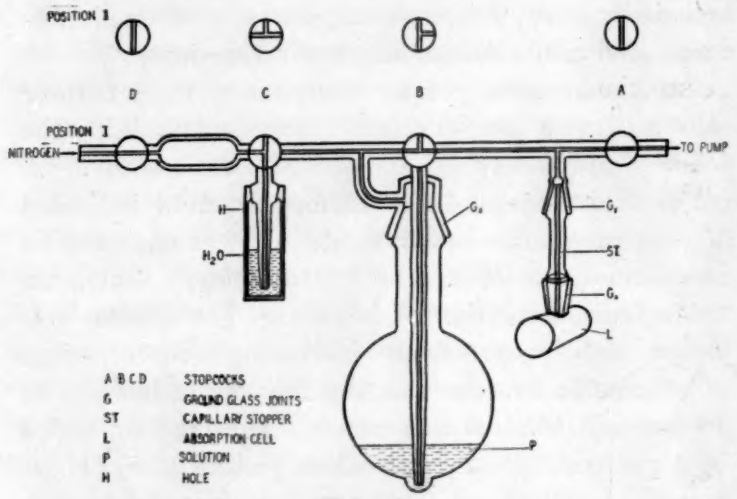

FIG. 1.

in which light absorption is to be measured. Another case is the introduction of air-free solution into a reaction cell for photochemical purposes, particularly when the analytical procedure involves spectrophotometry or colorimetry.

A very simple and widely used procedure which involves passing nitrogen through the solution is of limited usefulness. Thus in the case of protein solutions the customary method may lead to extensive foaming which results in loss of material and in denaturation of the protein. In all cases it is limited to solutions in which solvent and solutes are relatively non-volatile.

We present below a device which has been very useful in this laboratory and which seems to have general applicability. With the stopcocks A, B, C and D set as designated by "Position I," gaseous nitrogen is admitted at D and at the same time the other part of the system, including the absorption cell, is connected to a high vacuum pump for a few minutes. By gentle rotation of the flask the solution will be spread out and a very efficient removal of gas will take place. In order to transfer the oxygen-free solution to the cell L the stopcocks are adjusted as indicated by "Position II," where stopcock C should be operated last and rather gradually. With increasing nitrogen pressure the solution will be forced through the capillary and into the attached cell. The ground glass joint G_1 allows the detachment of the cell. The capillary stopper,[2] filled with solution, prevents the diffusion of air into the cell. In an alternative arrangement a stopcock is inserted in the capillary and closed at the conclusion of the transferring operation.

A modified procedure is employed in case the solution is volatile or has a volatile component. The flask is closed off by means of stopcocks B and C and its contents frozen by immersion of the flask in liquid air.[3] After temperature equilibrium is attained stopcock B is turned to Position I and the system evacuated, thus removing all non-condensable gases. Then, with stopcock B closed, the flask is heated to room temperature, whereby most of the dissolved air escapes into the vacuum above the solution. The process of alternate freezing, evacuating and thawing is repeated; it was found that three such steps sufficed to remove oxygen effectively from a 12 molar hydrochloric acid solution, the concentration of acid remaining unchanged within the accuracy of the analytical method employed (0.5 per cent.).

The method as described relies to some extent on the purity of the nitrogen used. However, one may employ commercial nitrogen and avoid contamination of the solution with oxygen if a surplus of the solution is available, for the top layer of the liquid will protect the portion which is to be transferred.

The authors wish to acknowledge their indebtedness to the Rockefeller Foundation for its support of the project in which this work developed.

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[1] From the George Herbert Jones Chemical Laboratory of the University of Chicago, Chicago, Illinois.

[2] O. Warburg and E. Negelein, *Biochem. Zeitschr.*, 214: 64, 1929.

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